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METHOD FOR THE QUANTITATIVE DETERMINATION OF THE
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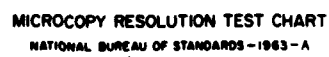
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METHOD FOR THE QUANTITATIVE DETERMINATION OF THE MINERAL
SALT CONTENT OF BONES USING RADIOACTIVE ISOTOPES

by

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METHOD FOR THE QUANTITATIVE DETERMINATION OF THE MINERAL SALT CONTENT OF BONES USING RADIOACTIVE ISOTOPES

J. Rassow, Dipl-Phys. Dr. ret. nat. and H. Struter

The invention concerns a method for the quantitative determination of the mineral salt content of bones on the basis of two measurements of attenuation with two radioactive isotopes of different photon energies.

The exact knowledge of the mineral salt content of the bones without shedding blood is of great importance clinically when it is a question of obtaining pathological findings which are or have been occurring because of a want of mineral salts.

A number of methods have already been proposed to determine these mineral salt components, which however were unsatisfactory because of too high systematic and nonsystematic errors. First the skeleton components were illuminated simultaneously with a reference system (for example bone equivalent stages) on an x-ray film, to obtain through a comparison of the blackening information on the mineral salt content. Moreover an attempt was made to determine from a difference of blackening of two films of the same part of the skeleton illuminated with different x-ray qualities along with a Plexiglass wedge, a comparison factor dependent on the mineral salt content.

Against these and other such methods the objection may be raised that the x-ray film is unsuitable as a detector for the quantitative data of the mineral salt content because of the relatively high nonsystematic fluctuations in blackening. Moreover the different effect of the soft scattered radiation on the blackening of the film cannot be eliminated with different object thicknesses.

The experiments carried out on bones in the form of measurements of blackening with a radioactive isotope provided a considerable improvement since by means of a scintillation detector and a pulse height analyzer any effect of the scattered radiation component was excluded. This method was based on the measurement of blackening of bone in a water bath to achieve a constant thickness. By disregarding the different mass

blackening coefficient of the connective tissue, the soft and fatty tissues as well as the water, however too large somatic errors continue to arise.

The invention is based on the problem of developing a clinically applicable method of examination with sufficiently low error level and avoiding the mistakes of known methods. The invention is characterized by the application of the following process stages:

- a) isotopes were selected according to their photon energy in such a way that it should lie above a lower limit of "too low energy" designed by a too large attenuation ratio $N_1:N_0$ and below an upper limit defined by too small differences between the attenuation coefficients for the soft parts of the connective tissue and bones, but would be at a sufficiently large distance from each other with regard to the different attenuation coefficients of bone and connective or soft tissue;
- b) with two isotopes selected by this means and using the same measurement geometry, equipment and an unchanged adjustment of the energy discrimination two measurements of attenuation each were carried out on the bones to be studied and in a single preliminary experiment on two bones of different but known mineral salt concentrations as well as zero measurements,
- c) through mathematical operations the connective tissue concentration is eliminated;
- d) the bone thickness occurring at the measurement point is established in particular by evaluation of an x-ray photograph;
- e) from the measurement values obtained in steps b through d the mineral salt content of the bone is determined.

The invention starts from the basic consideration that by means of a single standard measurement on two bones of different but known mineral salt content, the connective tissue concentration can be eliminated in the "patient's bone" and thus the mineral salt component in the bone can be strictly calculated. The determination of the soft tissues surrounding the bone can be omitted if this component of the radiation attenuation lies for a thin soft tissue mantle within the framework of the measurement error determined by the statistical nature of the radioactive decay. This is the case for example in the measurement of the heel bone.

Since no water bath needs to be used to obtain a constant measurement thickness, the arbitrary assumptions on the bone geometry and effects due to the apparatus are eliminated and the systematic errors are totally excluded. We obtain with the method based on the inventions such a low measurement error that nothings stands in the way of current clinical application of the method for determining mineral salt in the bones.

Continuing the invention it is proposed to use up to the bone thickness of 50 mm an isotope combination with photon energies of 25 to 50 KeV (for example iodine 125) and 50 to 100 KeV (for example americium 241), above a bone thickness of 50 mm a combination with photon energies of 50 to 100 KeV (for example americium 241) and 100 to 200 KeV (for example cobalt 57).

The inventors have published an article "On a Method of Quantitative Determination of Mineral Salt Content of Bones with Radioactive Isotopes" in the periodical "Fortschritte auf dem Gebiete der Roentgenstrahlen und der Nuklearmedizin" August, 1969 (Advances in the Area of X-rays and Nuclear Medicine). The purely theoretical and physical basis for this invention may be found in this publication.

Patent Claims

1) Method for the quantitative determination of the mineral salt content of bones using radioactive isotopes of different photon energy with which two measurements of attenuation are carried out per isotope, characterized by the following process stages:

a) isotopes are selected according to their photon energy in such a way that the latter lies above a lower limit of "too low energy" defined by a too large attenuation ratio $N_1:N_0$ and below an upper limit defined by too small differences between the attenuation coefficients for the soft or connective tissues and bone, but are at sufficiently large distance from each other with regard to the different attenuation coefficients of bone and connective or soft tissues;

b) with the isotopes selected in this way and using the same measurement geometry equipment and an unchanged adjustment of the energy discrimination, two measurements of attenuation each are carried out on the bones to be studied

and in a single preliminary experiment on two bones of different but known mineral salt concentration, also zero measurements;

c) through mathematical operations the connective tissue concentration is eliminated;

d) the bone thickness occurring at the measurement point is established in particular by evaluating an x-ray photograph;

e) from the measurement values obtained under items b to d the mineral salt content of the bone is determined.

2) Method according to claim 1 characterized by the fact that up to a bone thickness of 50 mm and an isotope combination of photon energies of 25 to 50 KeV (for example iodine 125) and 50 to 100 KeV (for example americium 241), is used, above a bone thickness of 50 mm a combination with photon energies of 50 to 100 KeV (for example americium 241) and 100 to 200 KeV (for example cobalt 57).